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INDIAN TEA ASSOCIATION

BACTERIA AND THE MANUFACTURE OF BLACK-TEA

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A REPORT ON RESULTS OBTAINED UP TO THE END OF 1932.

FOREWORD

The great emphasis laid, in the past few years, on the medical aspects of bacteriology has lead to a widespread idea that all bacteria are harmful to human life. This is far from being true,—many species being directly or indirectly indispensible in human economy.

Failure to distinguish between pathogenic bacteria, which cause diseases of animals and plants, and saprophytic species which can only attack dead tissues or chemical substances is responsible for this false impression.

The bacteria dealt with in this memorandum belong to the saprophytic group, and although some species are undesirable in the factory, their presence will not necessarily render the tea unfit for human consumption, although it may lower its market value, in extreme cases even to the point of making it unsaleable.

Bacteria, considered from the aspect of their effect on organic materials, are highly complicated organisms, and in tea manufacture their action on a complicated molecule—that of tannin—is being studied. The question of their effect on tea protein and non-tans is as yet untouched, and the whole subject presents many difficulties in study. This work is still in its infancy and many anomalous facts have emerged, as for example the rival claims of cement, glass, metal and cloth as a fermenting surface. Much work remains to be done before all the facts are obtained and methods evolved for the control of bacteria under all circumstances.

The object of this memorandum is therefore to call attention to several facts which are frequently overlooked, rather than to

serve as a guide to bacterial control methods. It is not intended as a scientific exposition of the subject, and many results of a purely scientific nature are omitted.

It will be shown that bacteria are always present on tea leaf, and the conditions will be indicated under which bacterial numbers may assume excessive proportions. Control methods which have proved satisfactory on a number of gardens will be discussed, but it cannot be too strongly emphasised that such methods may require modification to suit individual cases, and that their application in the factory should be carried out in closest co-operation with the Scientific Department.

To one unaccustomed to dealing with bacteria, it seems inconceivable that a single bacterium may develop into 16,000,000 in the space of 12 hours, yet failure to grasp this point has in some instances, undoubtedly led to lack of success with control methods in the past.

It is now generally thought in scientific quarters that the fermentation or oxidation of tea leaf during manufacture is brought about by the enzymes of the leaf, and not by micro-organisms. Early workers have stated that bacteria on the leaf increase during withering and manufacture, and that these organisms may play some part in fermentation, but the theory that fermentation is caused by such organisms was abandoned before the commencement of the present century. In non-scientific circles, there has remained a lingering idea that certain bacteria assist in fermentation, but at the same time it is recognised that taints may be caused by dirty fermenting floors. The possibility of the introduction of bacteria during other stages of manufacture has been generally overlooked in North-East India.

An intensive study of the whole question was therefore taken up some three years ago. New light has been thrown on certain defects of finished tea, the origin of which was previously obscure.

(Note :—In this memorandum, figures are employed to denote specific gardens, since it is contrary to the policy of the Department to disclose the name of gardens in publications. A record of the gardens so referred to is kept at Tocklai.)

SECTION I

The Occurrence of Bacteria on Tea Leaf and Their Subsequent Development

Several references to bacteria occur in the literature on tea. Among these may be mentioned the work of Bamber in Ceylon, and Mann in Assam. In 1916 Java workers isolated several different species of bacteria and three of these are described in a publication of that year. In general however, investigations on this line have been somewhat desultory and little attempt has been made to deal with the subject fully.

At the commencement of the research scheme in this Department it was observed that large numbers of bacteria are always present on the fresh green shoot, and the term "Tea bacteria" was applied to these organisms, all of which appear to be new species. They develop slowly on culture media, producing yellow, orange and pink colonies. It is not proposed to give a description of the tea bacteria in this memorandum, but some notes on their occurrence and properties are given below.

TABLE 1. DISTRIBUTION OF TEA BACTERIA ON THE SHOOT

Origin.	Number of bacteria per gram of material.		
	A.	B.	C.
Bud.	115,000,000	57,000,000	60,800,000
1st leaf ...	14,600,000	7,300,000	9,500,000
2nd leaf ...	5,100,000	2,450,000	1,270,000

The discovery of the Tea bacteria thus showed that the plucking shoot is literally covered with a thin film of bacteria. The distribution is interesting since the greater numbers are found on the finer portions of the shoot.

The fact that these bacteria are always present on fresh leaf forces one to assume that their presence is not detrimental to

quality, as at present understood. The group as a whole is very inactive, both in rate of growth and in its attack on nitrogenous substances and on sugars. Unpleasant odours have not been detected in cultures of these micro-organisms.

The degree of development is very variable. Not only do the total numbers differ on individual shoots, but the numbers of the different species also show wide variations.

THE "FOREIGN" BACTERIA

When samples of fermenting leaf and scrapings from floors and machinery in factories were examined a totally different bacterial flora was revealed. The Tea bacteria seldom developed, but very large numbers of rapid growing bacteria were found. These bacteria were assumed to have arisen as a result of infection from impure water supplies, material brought in accidentally by the factory labour, and from other external factors, and were therefore termed "Foreign" bacteria since they were not regarded as normal inhabitants of the tea shoot.

(Note :—In the remainder of this report the word "bacteria" will be taken as referring to the Foreign bacteria, unless Tea bacteria are specifically stated.)

The "Foreign" bacteria develop rapidly on lentil or beef extract media, and it appears probable that the organisms reported by earlier workers were confined to this group. Colourless colonies are obtained, and frequently strong odours are produced by the bacteria in pure culture, resembling sour milk, malt, stale fish, mice, etc. Only one pigment-forming species has been isolated to date, *viz.*, a minute yellow bacterium, which gives a pronounced "earthy" odour in culture, and the evidence points to the fact that this organism can be responsible for earthy taints in tea.

THE OCCURRENCE OF "FOREIGN" BACTERIA ON THE SHOOT

It has now been established that some of the so-called 'Foreign" bacteria are a normal constituent of the tea shoot, al-

though ordinarily present in numbers insufficient to be of consequence in manufacture. At the beginning of the season the numbers may vary from nil to 50,000 per gram of leaf; higher figures are frequently found in mid-season. The cause of this variation is not understood.

The distribution of the "Foreign" bacteria on the shoot is similar to that of the Tea bacteria, most being found on the bud.

TABLE 2. DISTRIBUTION OF "FOREIGN" BACTERIA ON THE SHOOT

Origin.	Numbers of bacteria per gram of material.		
	A.	B.	C.
Bud.	8,150,000	4,600,000	2,000,000
1st leaf ...	406,000	722,000	30,000
2nd leaf ...	154,000	100,000	2,760

Counts varying between nil and 2,000,000 bacteria on individual shoots have been recorded, but the average usually works out between 5,000 and 200,000 per gram of leaf. In the 1931 second flush teas made on garden 6, the total bacterial count was maintained at or below 50,000 per gram by careful supervision, and these teas obtained high prices on the London market.

The rapidity of growth of the "Foreign" species accounts for their preponderance in the factory. When juice has been expressed during rolling, the development of these bacteria is extremely rapid and the Tea bacteria are unable to compete for the available food. Tea bacteria are rarely found in material from factories, except at the beginning and end of the season, and in high-elevation gardens.

DEVELOPMENT OF BACTERIA DURING MANUFACTURE

It will be seen that fresh leaf carries to the factory a considerable number of bacteria, most of which appear to have little, if any, effect on fermenting leaf, while the more active species are present in relatively small numbers at this stage. The possibility of development during withering, rolling and fermentation has now to be considered.

The extreme rapidity of bacterial development is not always recognised, and the dangers of uncontrolled infection are frequently overlooked. The process of reproduction is of marked simplicity, the bacterial cell simply increasing in size and eventually dividing into two similar cells. Under favourable conditions of moisture, temperature, and food suply, this process may take place in half-an-hour. The two cells so formed pass through the same process, four cells being formed by the end of the next half hour. The rate of reproduction continues in this manner until the food supply is reduced, or until the substances produced by the bacteria have accumulated in sufficient amount to check further development. Thus a single bacterium allowed to develop for 12 hours could give rise to some 16,000,000 bacteria, or to 64,000,000,000,000 bacteria in 24 hours. There is therefore ample *time* for a considerable bacterial development to take place during the normal withering period of 18 hours or during a fermenting period of four hours, counting from the start of rolling.

Research conducted over the past year has shown, however, that under favourable manufacturing conditions, the actual development of bacteria within the mass of leaf is insignificant.

BACTERIAL CHANGES DURING WITHERING

A. The Normal Wither

The leaf does not appear to pick up bacteria from the chungs or racks on which it is spread. Even old hessian in a decayed state does not appear to affect the leaf when surface water is absent.

Leaf on garden 6 was spread on new and old hessian, the bacterial count being taken after withering. The results were :

New hessian : 24,000 bacteria per gram of leaf.
Old hessian : 30,000 ,, ,, ,, ,, ,,

The difference between these figures is within the limit of sampling error. On the other hand on garden 34, a peculiar ' corky'' taint was frequently reported, and the facts pointed to this being acquired through withering the leaf on decayed bamboo trays. Eleven experiments were run with leaf withered on these trays and on wire, and in each case a corky taint was detected on the former samples, those withered on wire being free from the taint. The discarding of the decayed trays has coincided with the disappearance of the taint from teas of the garden.

When dry leaf is withered there is no appreciable increase in the numbers of the bacteria originally present on the leaf.

TABLE 3. BACTERIAL CHANGES DURING WITHERING OF DRY LEAF

	Bacteria per gram of leaf.
Before withering ...	33,800
After 24 hours ...	30,000

B. THE WITHERING OF WET LEAF

When leaf is brought into the factory wet owing to rain, conditions become more favourable to bacterial development. Moisture, which is one of the vital requirements, is provided, and if there is sufficient "food" in the form of sugars, etc., secreted on the surface of the leaf, an increase in numbers is to be expected. The additional effect of heating in the plucking baskets has not yet been investigated.

When the leaf is spread on the withering racks or chungs, the excess moisture may dry off rapidly, unless the atmosphere is saturated. The effect of such conditions is shown in Table 4.

TABLE 4. BACTERIAL DEVELOPMENT IN WET LEAF ALLOWED TO DRY DURING WITHERING

Duration of wither.	Bacteria per gram of leaf.	
	Sample A.	Sample B.
Start	55,000	18,000
24 hours ...	200,000	2,150,000
48 hours ...	410,000	1,950,000

In sample B the surface moisture dried off more slowly owing to the high humidity of the air, and the greater increase in this sample may be attributed to this fact.

With the type of rainfall more common in the Brahmaputra Valley, *viz.*, rain storms alternating with dry periods, the increase of bacteria during the withering of wet leaf may not be a serious factor, provided that the free water evaporates from the surface of the leaf in reasonable time. Districts less fortunately situated climatically, such as parts of the Dooars where rain falls continuously for several days at a time, are exposed to a greater risk of infection as may be seen from the figures in Table 5, dealing with the increase of bacteria in leaf which remains wet during the withering period.

TABLE 5. BACTERIAL DEVELOPMENT IN WET LEAF, REMAINING WET DURING THE PERIOD OF WITHER

Duration of wither.	A.	B.	C.	D.
Start ...	7,100	18,000	55,000	18,000
24 hours ...	5,900,000	6,500,000	14,000,000	30,000,000
48 hours ...	47,000,000	146,000,000	40,000,000	62,000,000

It will be seen that under these conditions a high degree of bacterial development can take place. On some gardens with

adequate withering space, leaf is sometimes kept on the chungs for longer than the normal 16-24 hours wither, in an endeavour to obtain a physical wither during wet weather. The figures for a 48 hours wither are quoted above in reference to such cases. Infected teas,—even to the point of sourness,—may result unless the surface moisture is removed during the early stages of withering.

The effect of surface moisture is best examined by combining Tables 4 and 5. The figures given below represent bacterial development on the same sample of wet leaf, one half being allowed to dry, and the other half being kept in a humid atmosphere.

TABLE 6. EFFECT OF SURFACE MOISTURE ON BACTERIAL DEVELOPMENT

Duration of wither.	Bacteria per gram of leaf.	
	Wet leaf allowed to dry.	Leaf kept wet.
A. start ...	55,000	55,000
24 hours ...	200,000	14,000,000
48 hours ...	410,000	40,000,000
B. start ...	18,000	18,000
24 hours ...	2,150,000	30,000,000
48 hours ...	1,950,000	57,000,000

Normal withering therefore has little effect on bacterial numbers, and even wet leaf may not become seriously infected, if the surface moisture is removed quickly. It must be pointed out, however, that evidence exists to suggest that the "virulence" of certain species of bacteria varies according to their conditions of growth, and it is possible that a relatively high development of bacteria during withering can be tolerated although a similar

infection picked up in the factory might have an adverse effect on the fermenting leaf.

BACTERIAL CHANGES DURING MANUFACTURE AND FERMENTATION

Contrary to expectations, it is found that there is only a very slight increase in bacterial numbers during fermentation, when conditions are such that bacteria are not introduced from outside sources. The following figures were obtained from leaf rolled for 1 hour and fermented for four hours from the end of rolling.

TABLE 7. THE INCREASE OF BACTERIA DURING FERMENTATION

	Bacteria per gram of leaf.		
	A.	B.	C.
At end of roll ...	490,000	3,320,000	490,000
Fermented 4 hours	554,000	3,300,000	720,000

Although in most cases a definite increase is recorded, this is sufficiently small to be of little practical significance.

The figures bring out an important point, namely :—given clean leaf with a low bacterial count, the development of bacteria during a normal fermenting period of four hours is a negligible factor. An increase from 500,000 to 720,000 per gram is insignificant compared with the increase up to 28,000,000 per gram which, as will be shown later, may arise as a result of casual handling of the leaf in a contaminated factory.

INCREASE OF BACTERIA ON TEA HOUSE WASTE

If fermentation is allowed to continue beyond the normal time, as is the case with fragments of leaf and expressed juice left on floors and machines in the factory, bacterial development in-

creases in rapidity and within 12-24 hours, assumes high proportions :—

TABLE 8. INCREASE OF BACTERIA DURING EXTENDED FERMENTATION AT 86 F.

Bacteria per gram of leaf.

	A.		B.
Start ...	490,000	Start ...	2,580,000
4 hours ...	720,000	3 hours ...	3,530,000
8 hours ...	10,000,000	6 hours ...	10,000,000
12 hours ...	302,000,000	9 hours ...	249,000,000
20 hours ...	6,200,000,000	12 hours ...	2,300,000,000
24 hours ...	10,500,000,000	24 hours ...	11,300,000,000

In series B, the increase in each successive period of three hours is :

1st. 3 hours	...	1.37 times.
2nd. ,,	...	2.8 ,,
3rd. ,,	...	24.9 ,,
4th. ,,	...	10.4 ,,
Final 12 hours	...	4.35 ,,

Series A gives similar figures.

In other words, the bacteria in juice expressed from rollers at the start of manufacture, and those on fragments of leaf left attached to roller caps, ball breakers, etc., may have reached their highest state of activity before the end of the day's manufacture. At this stage the bacteria are doubling their numbers in a little over half an hour. The significance of this finding will be appreciated when the methods of bacterial control in factories are brought under discussion.

SECTION 2

THE CASE AGAINST BACTERIA

The methods by which bacteria can affect fermenting leaf are not yet fully understood and much work remains to be done in this sphere. The results of infection, however, have been brought to light, both by direct inoculation experiments and by instituting methods of bacterial control in factories.

It must be understood that it is not yet possible to foretell accurately the effect of any particular species either in pure culture or in the factory, although the general tendencies are known.

Bacteria are low forms of plant life consisting of single cells averaging 1/20,000 inch in length. In common with all forms of plant and animal life, they secrete enzymes, and their life processes are carried on through the action of these enzymes. Bacteria contain oxidising enzymes, similar to those in the tea leaf, and also enzymes capable of decomposing nitrogenous matter. In the latter case, free ammonia may be produced, or odours resembling mice, stale fish or meat, sour milk, excreta etc., and there is little doubt that these may sometimes be responsible for "earthy" "sour or cheesy", "baky" and other taints in tea.

There are thus two possible ways in which bacteria can affect the quality of fermenting leaf, *viz.*

(1) By the action of enzymes on the tannin in the juice on the surface of rolled leaf. Sugars and protein matter may also be affected.

(2) By the liberation of ammonia etc., which may affect the subsequent fermentation of the tea.

Since the bacteria to a great extent confine their activities to the juice on the surface of the rolled leaf, the maximum effect is likely to be found in the tasters five-minute infusion, in which much of this juice is dissolved.

EXPERIMENTS WITH INOCULATION

The results of experiments made by adding bacteria to leaf at Tocklai during rolling show that the above theories receive substantial confirmation in practice. The bacteria were isolated in the first instance from fermenting leaf or from infected residues from different factories, and in two cases a strained suspension of the residues themselves was used. The numbers of bacteria used in these experiments were comparable with the infection frequently found in fermenting leaf when manufacture is not conducted according to the requirements of bacterial control.

In experiments A, B and C the effect of bacteria on the tannin content of the leaf was determined by analysis of the finished tea.

TABLE 9. THE EFFECT OF BACTERIAL INFECTION ON THE TANNIN CONTENT OF TEAS

A. Check	14.77%	tannin
Inoculated	9·84%	,,
B. Check	16·58%	,,
Inoculated	7·27%	,,
C. Check	17·03%	,,
Inoculated	13·44%	,,

The drop in tannin consequent on bacterial infection is considerable. A further series of experiments was conducted with different bacteria isolated from fermenting leaf, the finished teas being submitted to a taster for report : In table *10* the results are given :—

TABLE 10. EFFECT OF BACTERIAL INFECTION ON TEAS

Sample.	Tasters Report.
1. Check	The cleanest tea *though rather lacking in* quality.
Inoculated A. / do. B. ...	Samples poor with an unclean taste and are softish. The soft and unclean taste has definitely affected the quality of the teas.

Sample.	Tasters Report.
2. Check	The cleanest tea and is bright, hard and pungent. Infusion bright.
Inoculated	Though fuller, is rather soft and a trifle sweaty.
3. A. Check	A is preferable to B as it is brisk and clean, while B tastes rather unclean and appears to be a non-keeping type.
B. Inoculated	
4. C. Check	D. the inoculated sample is rather soft.
D. Inoculated	

All the above inoculations were made with cultures of bacteria. In the following experiments, the leaf was inoculated with infected material from factories, suspended in water and filtered through cotton-wool to remove the dirt, while retaining the bacteria in suspension.

TABLE 11. EFFECT OF A MIXED SUSPENSION OF BACTERIA ON TEA

Samples.	Tasters Report.
5. E. Check	E is a cleaner, brighter tea than F with more character. F is a little fuller than E, but is soft and tastes unclean.
F. Inoculated	
6. Check	Infusions of all sets are fair but a little uneven. In cup, the liquors marked Bacteria are soft with colour, whereas the check samples have briskness with very good strength.
Bacteria (Inoculated)	

It must be pointed out that all bacteria may not produce these effects, and the study of individual species provides an important subject for future consideration. There is also

evidence that the activity of bacteria growing naturally on tea juice and leaf in factories is much greater than that of the same species when obtained in pure culture.

It is clear, however, that certain micro-organisms commonly found in factories may have a marked deleterious effect on fermenting leaf, and that this effect persists in the finished teas.

The results of the experiments quoted above, and of work in factories, show that the ill effects are mainly in the direction of

(1) Dull infused leaf.
(2) Soft liquors.
(3) Taints.

An interesting point, which was not foreseen, is that an infected tea may throw a more coloury, though softer, liquor than one manufactured under clean conditions. When milk is added to such liquors however, the colour is usually found to be coffee like, or "grey" and "slatey" instead of the bright orange or pinkish colour of a quality tea.

A further interesting point on dull infused leaf was brought out in 1931. In the past there has been a tendency to assume that dull infused leaf is a sign of over-fermentation. By careful control of bacterial infection it has been found possible to ferment leaf for 24 hours without the development of a dark colour on the leaf. This is not always possible, except at the beginning of the season when bacterial counts and temperatures are low, owing to the rapid development of bacteria in the leaf itself, but by adding to the leaf a chemical which prevents bacterial development, a bright colour was still obtained at the end of three days fermentation. A dull infusion cannot therefore be directly ascribed to over-fermentation.

It is interesting to note that the Ceylon workers reported a similar finding at about the same time.

SECTION 3

THE ORIGIN OF BACTERIAL INFECTION IN THE FACTORY

It has now been shown that most tea leaf carries the so-called "Foreign" bacteria, but that the numbers are low, and that unless a high degree of development has taken place, owing to leaf remaining in a wet condition in the withering house, the withered leaf should reach the rolling room with a relatively low infection.

It has also been shown that bacterial increase during fermentation is slight, but that after the first few hours these bacteria multiply rapidly on waste leaf or in expressed juice, and that if these bacteria are allowed to reinfect the leaf, dull infusions and soft liquors may result.

Bacterial control thus becomes a question of preventing the increase of bacteria in waste material, removing the waste material as it arises, and as far as possible keeping the leaf out of contact with places where bacteria may be developing. In this section the main sources of infection will be indicated.

A. INFECTION FROM ROLLERS

Unless continually cleaned, rollers quickly accumulate residues of leaf, and bacterial development is rapid. Juice and leaf particles collect in the angles of the battens on the cap and in the ventilating holes which are provided in some types of pressure cap. When the cap is fairly clean, and only a thin layer of dried juice is present, bacterial numbers are relatively low, but when deposits are heavy and in a moist state, excessive infection is frequently found :—

TABLE 12. BACTERIAL INFECTION ON ROLLER CAPS BACTERIA PER GRAM OF MATERIAL

Light dry deposits.	Heavy moist deposits.
140,000,000	1,960,000,000
240,000,000	3,910,000,000
282,000,000	1,750,000,000
83,000,000	2,75,0000,000
93,000,000	

Even higher infections may be found in deposits from roller tables, where the latter are of wood or cement, and are in a decayed state. Pockets in the surface of the table tend to collect leaf and juice, such material remaining moist.

Typical figures are :

TABLE 13. BACTERIAL INFECTION ON CEMENT AND WOOD ROLLER TABLE

1,930,000,000	bacteria	per gram.
5,200,000,000	,,	,,
7,660,000,000	,,	,,
8,030,000,000	,,	,,

B. INFECTION FROM GREEN-LEAF SIFTERS

Owing to the large surface exposed by the wires of these machines, they can contribute a considerable infection to leaf passing over them. Typical figures for material left adhering to the wires are given in Table 14. (All figures for material scraped off machines, floors, etc., represent the infection which may be present if these are not cleaned daily).

TABLE 14. INFECTION ON GREEN-LEAF SIFTERS

3,600,000,000	Bacteria	per gram of material.
2,650,000,000	,,	,,
9,150,000,000	,,	,,
6,320,000,000	,,	,,
25,000,000	,,	,,

Here again the lowest figures are obtained when heavy deposits are not allowed to accumulate. The infection which may be transferred to leaf, even at an early stage of manufacture, by an uncleaned sifter is shown by the following figures for rolled leaf before and after sifting.

TABLE 15. INFECTION OF LEAF BY A GREEN-LEAF SIFTER

Before sifting	30,000	bacteria	per gram.
After sifting	480,000	,,	,,

These figures represent the first sifting only. Since coarse leaf may be passed over the sifter three times, with an increasing

infection each time, unless cleaning is adequate a high degree of infection may eventually by reached.

C. INFECTION IN LEAF TROLLIES

Leaf trollies being constantly brought into contact with expressed juice, which is absorbed by the wood, would be expected to provide an excellent breeding ground for bacteria. Such deposits are frequently moist, and bacterial numbers are high in consequence.

TABLE 16. BACTERIAL INFECTION IN WOODEN LEAF TROLLIES

3,000,000,000	bacteria per gram of material.
1,460,000,000	,, ,,
980,969,000	,, ,,

D. INFECTION ON ROLLING ROOM FLOORS

The floor of the rolling room provides what is probably the most dangerous source of infection in the whole factory. Often in poor condition and badly drained, the floor is constantly contaminated with juice expressed from the rollers. Even a floor of Indian Patent Stone breeds a high infection by the end of the day, unless steps are taken to remove the juice as it falls, and where the floor is porous and in poor condition the residues from previous manufactures may transfer a high infection to freshly expressed juice.

Figures for dirt scraped off the floor underneath the rollers are :

TABLE 17. BACTERIAL INFECTION ON ROLLING ROOM FLOORS

1,180,000,000	bacteria per gram.
490,000,000	,, ,,
1,660,000,000	,, ,,
610,000,000	,, ,,
1,480,000,000	,, ,,

Even when a floor is reasonably well cleaned and bacterial numbers thereby reduced, a full infection is likely to develop during the day.

TABLE 18. DEVELOPMENT OF BACTERIA ON A ROLLING ROOM FLOOR

Before manufacture	200,000,000	bacteria per gram.
After manufacture	2,700,000,000	" "

The extent to which bacteria can be picked up by leaf dropped on to an infected floor covered with juice is well brought out by figures obtained at Garden 21. In this case, the leaf trollies were of small size and consequently some 25% of the leaf was dropped on to the floor at the end of the roll. The floor was of Indian Patent Stone and in good condition, but was badly drained, and the expressed juice remained on the floor. The leaf dropped into this juice immediately acquired an infection of 28,400,000 bacteria per gram. This leaf was bulked with the rest. The infection in the fermenting leaf was 7,500,000 bacteria per gram.

Analysis at another garden where less leaf was dropped under the rollers in the normal course of manufacture gave the following figures :—

TABLE 19. INFECTION OF LEAF BY ROLLING ROOM FLOOR

Fermenting leaf after normal handling	1,820,000	bacteria per gram.
" " kept off the floor	168,000	.. " ..

The possibility of such infection will vary in different factories since in some cases very little leaf is dropped, while at the other extreme, one factory has been visited where the whole roll was dropped directly on to the floor.

E. INFECTION ON FERMENTING FLOORS

Fermenting floors vary from glazed tiles and glass beds, to decayed brick from which the original surface of cement has almost completely disappeared. Glass sheets and tiles, if kept clean, may be regarded as practically sterile. The analyses of scrapings from many cement floors show that the bacterial infection is again roughly proportional to the amount of dirt present and its degree of moistness. Good floors of Patent Stone or cement as a rule carry only a thin film of tea juice, and unless the floor

is continually washed, this film is dry. Bacterial counts on such floors are generally lower than in the heavy deposits from decayed floors, particularly if the latter are kept wet.

TABLE 20. BACTERIAL INFECTION ON FERMENTING ROOM FLOORS

BACTERIA PER GRAM OF MATERIAL

Thin dry deposits.	Heavy moist deposits.
16,200,000	389,000,000
450,000,000	1,530,000,000
80,000,000	4,450,000,000
36,000.000	8,490,000,000
470,000,000	6,450,000,000

Damp porous floors appear to support higher numbers of bacteria than do dry floors. In addition, the former commonly become infected with a bacterium which gives a strong "earthy" odour in pure culture, and there is distinct evidence that this organism is responsible for an "earthy" taint in teas. These bacteria have been found on a number of occasions in the white patches which develop on porous floors during the cold weather.

On the fermenting floor, two effects may be expected, one caused by the actual entry of the bacteria into the mass of fermenting leaf, which can only affect the lowest portions of the "bed" and which probably takes place when the floor is wet, and the other caused by the gases (*e.g.* ammonia) produced by bacteria acting on old or on freshly deposited juice and on the leaf in contact with the floor, rising through the whole mass.

An extreme case of bacterial infection from a fermenting floor is found in the following figures from a garden where leaf fermented on wire racks was preferred to that fermented on the floor.

TABLE 21. INFECTION OF LEAF ON A FERMENTING FLOOR

Leaf fermented on rack	300,000	bacteria per gram.
Leaf fermented on floor	41,600,000	,,

SECTION 4

THE CONTROL OF BACTERIAL INFECTION IN FACTORIES WITH SOME RESULTS OBTAINED IN PRACTICE

The results of bacterial infection will depend on a number of factors, such as the species of bacteria concerned and their activity at the time of infection, the number introduced, the length of time these are allowed to act on the leaf, the temperature of the leaf, etc. It is therefore possible for one factory to produce good teas although working under unclean conditions, while another factory may have to adopt intensive control measures against bacteria if good teas are to be made.

The maintenance of cleanliness in the past has been attempted by washing with water, steaming, and by the use of permanganate of potash on the fermenting floor. Constant washing of the latter has also been practised, although evidence now points to the fact that this treatment may fail to have the desired effect.

The methods put forward by this Department in the last three years have been based on an appreciation of the factors concerned in bacterial development, and of the points at which infection is most likely to occur. The main features of these recommendations are :—

(1) Introduction of blow lamps for sterilising machinery.

(2) Recognition of the fact that rolling room floors can seldom be kept sterile under present conditions.

(3) Elimination of absorbent wood surfaces.

(4) Attempts to control bacteria by removing their food (*i.e.* dried juice, etc.), and by eliminating excess moisture.

These methods on the whole have produced successful results, although failures have been met in some instances, owing to the difficulty experienced in cleaning certain types of fermenting floors.

A. STERILISATION OF ROLLERS

Before routine treatment can be taken up it has been found necessary to clean away all old deposits from roller caps, tables, etc. otherwise subsequent flaming with a blow lamp is not efficient. The method of cleaning that so far has been found to be most satisfactory in practice, is a thorough brushing with water at the end of the day, followed by flaming with blow lamps before manufacture starts next day. The necessity of both cleaning and flaming is shown by the following figures :

TABLE 22. DEVELOPMENT OF BACTERIA ON ROLLER DIRT DURING THE DAY

Scrapings before manufacture starts	242,000,000 bacteria per gram.
Scrapings at end of manufacture	5,930,000,000 ,, ,, ,,

The leaf particles on which these bacteria are developing must be washed away, but the water left on the roller cap encourages bacterial development in the insoluble residues not removed by washing. In one sample taken from a roller cap washed at night, scrapings taken before flaming next day showed 3,000,000,000 bacteria per gram of scrapings. Rollers should not be flamed when wet, since a layer of steam may be formed between the flame and the wet surface, and this protects the bacteria from the intense heat of the flame.

The use of a large torch simplifies the process of flaming and enables the work to be done more quickly than when the ordinary small blow-lamp is used.

The danger of infection from uncleaned rollers is brought out by the following report from a garden Manager (1). An experiment was tried in which the rollers were washed once a week, cleaning being attempted at the end of each day without using water.

> "We gave it a trial for a week or more, trying to clean only with blow lamps and keeping everything dry .... After a few days the colour of the infused leaf became affected and was a dirty dark brown. After a few days of

this, I washed down thoroughly with sand and water and polished the tables up, and the colours came back at once."

This is particularly interesting as giving direct evidence of bacteria being instrumental in the production of dull infused leaf.

Another Manager (2) states that if he omits the daily flaming of rollers and sifters, the infused leaf is always darker and liquors are less pungent.

B. STERILISATION OF GREEN LEAF SIFTERS

Flaming the wires of kutcha sifters was adopted in 1930 and has proved satisfactory in practice. The method now used is to brush the sifters with water at the end of the day, flaming them thoroughly before commencing manufacture next morning. Brushing alone detaches the large pieces of leaf from the wires, but the machine soon becomes clogged with a "fur" of small particles and dried juice. Flaming, apart from destroying the bacteria, causes this fur to char and shrink, when it is easily removed with a dry brush.

One Manager (3) reported a complete alteration in the character of his teas to coloury pungent liquors with bright infused leaf, when the flaming of rollers and sifters was adopted, together with keeping the factory floors dry.

Corresponding invoices for 1930 and 1931, the latter with bacterial control, were reported on as follows :—

	1930	1931
Liquors ...	Some briskness, very light and wanting in substance	Strong, coloury, brisk with some quality and a little flavour.
Infused leaf	Fair but rather uneven.	Bright.

Another Manager (4) states that flaming is the only satisfactory way of cleaning a green leaf sifter.

In many cases where flaming has been adopted, it is not possible to ascribe the improvement in the teas to this treatment alone, since other methods of bacterial control have been adopted at the same time.

C. LEAF TROLLIES

At first, attempts were made at keeping leaf trollies clean by scrubbing with E.C. solution. It was found that new trollies, well made, could be cleaned in this way but that they became fully coated with juice after one day's manufacture. Old trollies could not be dealt with. To avoid the rapid accumulation of juice and to simplify cleaning and sterilisation, metal linings were subsequently recommended, and these have been widely adopted. Such trollies are kept clean with the minimum of trouble; simple washing at night, and if possible, at intervals during the day, and flaming before the start of manufacture is sufficient. No definite reports on the results of installing metal linings have been received, since in nearly all cases this provision was adopted with other methods of bacterial control.

D. FLOORS OF ROLLING ROOMS

Investigations made over a considerable period have shown that the rolling room floor can only be kept free from dangerous infection under two conditions, *viz.*

(1) If no juice is dropped on to the floor.

(2) If the juice is completely removed as soon as it falls on to the floor.

Owing to the rapid development of bacteria in tea juice, a heavy infection may occur even on a tiled floor by the end of the day, if the expressed juice is allowed to remain on the floor.

A comparative effect is seen in figures from garden 27, where the expressed juice was allowed to run through cloth suspended on wire racks, the leaf remaining on the cloth. Although this cloth was sterile at the start of manufacture, subsequently bacterial development was rapid. After nine hours manufacture, fine leaf freshly dropped on to this cloth was found to have

acquired a bacterial count of 11,600,000 bacteria per gram through contact with infected juice, although the leaf only remained on the cloth for a few minutes. The average infection on the main bulk of leaf was only 58,500 bacteria per gram, so that the infection picked up from the cloth amounted to 11,540,000 bacteria per gram of leaf.

To render possible the removal of juice as it falls, a special *construction of the floor* under the rollers is required. A satisfactory design is already found in a few factories, and consists of a fairly steep slope of the floor from front to rear, into a drain situated behind the machines. To secure this effect, the rollers may either be mounted on a steeply cambered floor, or individual pits may be provided for each roller.

If the juice is washed off this slope as it falls, or at least every half hour, a low degree of bacterial development may be expected. The function of the slope is to prevent juice and water from flowing out in front of the machines when the floor is washed.

Figures obtained in practice for leaf allowed to fall on to the floor underneath the rollers are:

TABLE 23. INFECTION OF LEAF BY ROLLING ROOM FLOOR

Undrained floor	...	28,400,000	bacteria per	gram	of leaf.
Drained floor frequently washed	...	1,700,000	..	..	..
	...	1,340,000	..	..	..

With a correct design of floor and constant washing, the surface can be kept relatively clean and free from bacteria, but where these facilities do not exist, leaf must be kept off the floor. In cases of serious infection, it has been found necessary to discard all leaf which falls on to the rolling room floor wherever juice has collected.

A major fault in factory procedure has been revealed by this work, *viz.*, the bulking of withered leaf on the floor in front of the rollers. Observation has shown that when the floor is contaminated with juice, such leaf frequently develops an unpleasant odour, presumably owing to bacterial infection.

Withered leaf should be bulked on a wooden platform or a tarpaulin, or loaded direct into the rollers. In any case it should be kept off the floor.

The following figures from a group of four gardens are interesting. Garden A was working with a well drained rolling room floor, all juice being washed away as it fell. Gardens B, C and D had undrained floors and large amounts of leaf were dropped into the juice which flowed over the floor. The final infection in fermenting leaf from the different gardens was :—

TABLE 24. INFECTION OF LEAF FROM ROLLING ROOM FLOOR

Garden A (floor drained)	...	138,000	bacteria per gram.
„ B (floor undrained)	...	7,040,000	„
„ C „ „	...	5,000,000	„
„ D „ „	...	28,600,000	„

RESULTS OBTAINED IN PRACTICE

Garden 5 was accustomed to making teas with a rather dull infused leaf, and liquors somewhat lacking in pungency. Test fermentations were made on glass sheets and showed a slight improvement. The rolling room floor, although of Indian Patent Stone, was thickly coated with old juice residues and was considered to be the source of infection, since juice from the rollers flowed in front of the machines, towards the only drain. The rolling floor was subsequently kept very clean and all leaf falling into juice was discarded. Sifters and rollers were flamed each day, and leaf trollies were metal-lined as an additional precaution.

The Manager later reported that infused leaf was brighter and liquors more pungent than had been the case for some years.

Garden 6 had an undrained rolling room floor, and the whole floor was kept wet by spraying water into the air for cooling purposes. Infused leaf was always dark and liquors tended to be plain.

A drain was cut behind the rollers, for the removal of water after washing the machines. Floors were kept as dry as possible, and leaf falling on to the floor was discarded. An immediate improvement in infused leaf and liquors was noted. Corresponding invoices for 1930, and for 1931 after bacterial control had been introduced were reported on as follows :—

	1930	1931
Liquors.	Are a little light in description and are rather plain in cup lacking point and briskness.	Strong and coloury with point and pungency.
Infused leaf.	Is greenish and rather dark in colour.	Bright and even.

A report by the Manager of this garden is given in Section 5. Garden 7 was reported to be making "sourish" teas. Leaf was fermented on tiles, but an infection from the rolling room floor was diagnosed. Since control measures were instituted, no complaint of sourness has been received, and the Manager stated that infusions were brighter immediately after the change.

Garden 8 was in the habit of bulking withered leaf on the rolling room floor, which was badly drained, and covered with juice. Leaf was also dropped on to the floor during subsequent stages of manufacture. When these practices had been stopped the Manager wrote: "Since your visit I have been keeping my rolling floor dry, and anyhow have kept the kutcha leaf off the floor. My infused leaf is a better colour and liquors are brisker, and this has been borne out by my brokers reports."

E. CONTROL OF INFECTION IN THE FERMENTING ROOM

The cleaning of fermenting floors in the past has usually been attempted by scrubbing with water or with a very dilute solution of permanganate of potash. Steaming has sometimes been adopted for sterilising purposes.

When the first experiments were made at sterilising floors it was found that even concentrated solutions of permanganate of potash had a very incomplete effect on the bacteria. When using a solution containing one ounce permanganate of potash per gallon added to scrapings from a fermenting floor the following figures were obtained.

TABLE 25. STERILISATION BY PERMANGANATE OF POTASH

Control	740,000,000	bacteria per gram.
Permanganate solution allowed to act for 5 minutes.	192,000,000	,,
30 minutes.	160,000,000	,,

The pink solution used in factories has a concentration of about one-hundredth of that used above. It is therefore doubtful if the treatment is much more effective than scrubbing with plain water.

Many antiseptics could not be used on account of their odour, and as a strong oxidising agent, Electrolytic Chlorine was adopted, since this has the advantage that the free chlorine is destroyed by organic matter. E.C. was found capable of completely destroying bacteria in pure culture. For spore-forming bacteria its use at a temperature of 140°F. was required When the solution was used in the factory, however, it was found that the oxidising power of the free chlorine was destroyed by the dirt present, before the bacteria had been killed. It was thus realised as early as 1930, that E.C. could not be regarded as a true sterilising agent, unless the surfaces to be treated were completely free from organic matter, but its power of decomposing organic matter rendered this reagent of great use in assisting the cleaning of a floor.

It is proposed to deal with the E.C. treatment for fermenting floors in a separate pamphlet since the subject is complicated. E.C. when correctly applied has given satisfactory results in a number of gardens, and it is still being used. Failures have arisen, which can be ascribed to :

(1) The use of E.C. on a porous or decayed floor which cannot be satisfactorily cleaned.

(2). The use of E.C. as a wash without attempting to clean the floor.

(3) Failure to wash the floor after treatment.

These errors all arise from the faulty assumption that E.C. is used as a sterilising agent, whereas the original intention which gave rise to its introduction for factory work was that it should assist the process of cleaning the dirt off the floor. Its sterilising action is not exerted as long as any organic matter remains.

WET FERMENTING FLOORS

The constant washing of fermenting floors has been discouraged since work on bacterial control was taken up, as the result of experiments. Figures given on page 21 show that a higher degree of infection is found in moist deposits than in dry. When moist deposits are allowed to accumulate, unpleasant odours frequently appear, but these odours are due to the products of bacterial action, and not to the bacteria themselves. Thus lactic acid and similar organic acids may give rise to a sour or "cheesy" smell; ammonia and various amines may produce stable-like or "fishy" odours. These substances are usually soluble in water, and in consequence washing may remove the odour temporarily, but unless the floor is thoroughly cleaned at the same time, the bacteria will remain and will be stimulated to further activity by the moisture supplied.

Cleaning with sand and water, with E.C. where the state of the floor allows this reagent to be used successfully, is therefore advised, to remove the deposits of juice on which the bacteria are developing, the floor subsequently being kept dry to inhibit further bacterial development on freshly deposited juice. This system has given good results in a number of gardens.

The Superintendent of a group of gardens (13) reported that when leaf was fermented on a wet floor, the leaf in contact with the floor always gave a softer liquor than that forming the upper half of the bed.

On Garden 20, leaf was fermented on wet and dry floors. The samples from the dry floor gave brighter infused leaf and brisker liquors.

The Manager of Garden 8 reports "Last year I found that we got a great improvement in infused colour when fermenting on a dry floor—also a great decrease in the smell of ammonia". In this case flaming of the green leaf sifters was adopted at the same time, and some of the improvement may have been due to this.

Teas fermented on a dry floor are not always preferred to those from a wet surface, and it appears that a temperature factor may be involved, the wet floor being cooler than the dry, so that if a definitely harmful bacterium is not present on the floor, wet conditions may be satisfactory. This of course is a matter for individual experiment.

HUMIDIFIERS AND WATER SUPPLIES

Humidifiers correctly installed and worked should not deposit water on the floor. In low, badly ventilated rooms, deposition may occur, especially if the humidifiers are worked continuously in a naturally cool room where very little moisture is necessary to saturate the air. This introduces the effect of wet fermenting floors dealt with in the last paragraphs. Gardens 21 and 22 reported that teas were improved when the use of humidifiers was discontinued. Garden 23 also stopped the use of humidifiers when it was found that leaf in contact with water on the floor gave a dull infusion.

These findings should not be taken to indicate that a cool, humid atmosphere in the fermenting room is not considered desirable, but that if these conditions can only be secured at the expense of a wet fermenting floor, the effect of the increased bacterial activity on the floor may more than outweigh the benefit of a humid atmosphere.

A secondary effect is introduced when the water supply is highly infected with bacteria. Most supplies in the plains are surface waters and high infections are often found. The first

case investigated was that of Garden 24 where the leaf fermenting underneath the humidifiers developed a highly unpleasant smell, comparable to a "baky" taint. The water supply was found to be highly infected with bacteria, up to 104,000 per cc. being recorded.

The origin of the infection was apparently seepage through the walls of shallow wells. When this factor had been eliminated and precautions were taken to exclude foreign matter from the wells, the bacterial count fell to 200 per cc. and the taint has not occurred since.

Two further instances of infected water supplies may be given. At Garden 25, a general bacterial infection was first brought under control, attention being subsequently directed towards the water supply. This consisted of a 40 ft. tube well which was evidently tapping an underground channel of polluted water. Counts up to 400,000 bacteria per cc. were obtained.

A taster reports "Up to and including last season (garden 25) teas always had dull poor infusions and the liquors had a rank sourish taste. Last year measures were taken to control the bacteria and the tea improved considerably, though the infusions were still dull and the liquors sourish. . . . This year, water for use in the factory is taken from a different source, bacterial control is still in force and the infusions this year are bright and the liquors are pungent with no trace of sourness".

Garden 26 provided a similar case and the same precautions eliminated the sourness and improved the teas.

These instances are sufficient to show that an infected water supply may be an important factor in preventing the production of good teas. A new line of work has thus been opened up. Water samples have been examined with infections ranging from a few hundred to more than two million bacteria per cc. and the clearness of the sample is no criterion of its purity.

FERMENTATION OUT OF CONTACT WITH THE FLOOR

It has now been shown that infections on the fermenting floor can seriously affect the teas but can be controlled to some extent

by removing the film of tea juice which accumulates rapidly, and by maintaining dry conditions. E.C. has proved of value in assisting the cleaning of floors in many cases, but the treatment requires careful supervision, and certain types of floor will not respond to any cleaning process. The failure of the E.C. treatment when applied to decayed floors has unfortunately led to a general abandonment of this method, even for good floors, and a simple and effective way of cleaning floors in good condition is hence being disregarded.

Relaying of an infected floor is no guarantee that a non-porous surface will be obtained, unless the work is done by experts. A porous floor may become fully infected in the first season. A logical development is therefore fermentation out of contact with the floor.

Early in 1930 the use of metal sheets was advised for testing the effect of the fermenting floor on teas, leaf spread on the sheets being compared with similar leaf spread on the floor. As a further development, wire racks covered with clean cloth were advised. Rack fermentation is not a new system, but has recently been adopted by a number of gardens which formerly fermented on the floor. Where the floor is infected and cannot be cleaned, fermentation on racks or metal sheets has frequently given brighter infused leaf and stronger liquors.

The following are instances.

Garden 27. London Broker's report.

A. Leaf fermented on racks.
B. Leaf fermented on the floor.

"Dry leaf : There is nothing to choose in make of leaf between the two sets."

"Liquors : We give decided preference to A. They are thicker, have better quality, and are brisker than B."

"Infused leaf. A is brighter and more even than B."

Valuations (London).		B.O.P.	B.P.
A. (racks)	...	1/5	8½
A. (floor)	...	1/2½	7½

Garden 21. Calcutta Broker's report.

C. on racks

D. on floor.

"As regards dry leaf there is little to choose between the appearances of either set."

"The infused leaf of C set however, is preferable being brighter in colour, and in cup we also give distinct preference to the C samples which were fermented on wire racks. This set throws brighter liquors, and are more pungent in character than those of D samples."

Garden 28. Calcutta Broker's report.

A fermented on zinc sheets.

B fermented on floor.

"With reference to the samples manufactured on the 21st. June, 1931 we certainly prefer the liquor of the A. It is though light, fairly sweet. The liquor of the B is plainish."

Garden 17. Calcutta Broker's report.

Samples A. fermented on floor.

Samples B. fermented on galvanised iron sheets. The leaf was not allowed to touch the floor at any stage of manufacture.

"On the infused leaf there is nothing to choose between the two sets. In cup however, B are distinctly preferable as regards strength and quality."

Garden 14. The Manager writes "Rack fermenting adopted this season (1932) has already proved of great benefit to quality". This garden was visited by the Bacteriologist who was informed by the Manager that the adoption of rack fermentation had been accompanied by brighter infused leaf than had been seen for a number of years, and the disappearance from the liquors of a soft character which had been continually reported in previous seasons. The use of E.C. in 1931 had improved the infused leaf colour and the liquors but the floor could not be kept clean, and rack fermentation was finally adopted.

When using wire racks for fermentation, unsatisfactory results are sometimes obtained through overheating of the leaf. If the wire is allowed to sag, an excessive thickness of spread may occur in the centre of the rack, and this is undoubtedly a contributory factor. The chief mistake however, is that of piling the racks on top of each other. With a thin spread of leaf, very little rise in temperature occurs, but a thick spread on racks placed close together has resulted on occasion in a temperature difference of 5°F between top and bottom trays.

This practice is quite unnecessary. If the floor space is sufficient for the leaf when spread on the floor, it will be almost sufficient for the same surface area of racks placed side by side, and there is no reason why racks should be piled up four deep, leaving a large portion of the floor space unoccupied.

The methods outlined above for avoiding bacterial infection in factories have proved workable in practice, and have given satisfactory results when closely followed, in cases where a bacterial factor was concerned.

The increase in infection throughout manufacture was determined in one factory where these methods had been adopted. The following figures were obtained :—

Stage of manufacture.	Bacteria per gram of leaf.
Withered leaf	40,000
After first roll	34,000
Coarse leaf after first sifting... ...	40,000
After second roll	116,000
Coarse leaf after second sifting ...	166,000
After third roll...	180,000
Coarse leaf after third sifting ...	184,000
Fermenting leaf ½ hour before firing ...	192,000

The only stage at which infection is still occurring is during the second roll and sifting, probably owing to some residual contamination with expressed juice. The slight increase in bacterial numbers at other stages may be attributed to normal bacterial development.

SECTION 5

Further Results of Bacterial Control in Practice

In the final section of this memorandum, further instances of the results of bacterial control methods in factories are given, and fuller reports on certain cases, which have already been referred to, are included.

The undermentioned Tasters reports have been received in respect of gardens where control methods have been practised.

Garden 17. "Bacterial control has considerably improved the teas on this garden. At the beginning of last season, the teas suddenly became dull, poor soft tyes, with dull black infusions. This was found to be entirely due to the poor condition on the fermenting room floor. For some time after this, Garden 17 fermented on corrugated iron sheets, but it was found that after these had been used a month or so the galvanising wore off and the standard of the teas went back. Wire fermenting racks were then constructed and have been used ever since with good results."

Garden 31. "(Garden 31) is a case in point where a definite improvement was noticed when fermentation was carried out on zinc sheets instead of on the floor."

Garden 33. "(Garden 33) is another garden where infusions and liquors have improved out of all knowledge due entirely to bacterial control. Bacterial control was in force last year, but the floors throughout were so bad that it was impossible to obtain completely sterile conditions, last cold weather the floors were relayed and an immediate improvement was noticeable."

A taster reports :—"A decided improvement has taken place on our Cachar and Sylhet gardens by introducing bacterial control. The liquors from all our gardens have, I consider, become brighter and more pungent since they have worked under sterile conditions."

The following opinion of a taster on the effect of bacteria on tea is of interest :—

"In your letter of the 23rd June you ask whether I consider that bacteria can definitely be held responsible for dull infused leaf and soft liquors. In my opinion there is no doubt that this is so."

"A bacterially infected tea is, I think, easier to detect when tasting with milk than without. Such teas frequently have the effect of turning the milk sourish, when if no milk had been added, the same tea might have been called 'a little soft'. (*Note* this softness differs from that caused by stewing). Further, the bulked tea takes up a dull to grey slatey colour (with milk) according to the extent of the infection. The large blenders at home neglect grey or slatey teas."

"Again a bacterially infected tea may have no objectionable character, but may taste 'meaty' or full, without point or briskness ; this 'meaty' character is not a true tea characteristic."

"A point of interest is that teas made under sterile conditions often *look thinner* than before such conditions were introduced but are almost invariably thicker on the palate."

"Where fermenting floors have been bad we have experimented in fermenting alternate gunnies on zinc sheets and tasted them against those fermented on the floor. Where the floor was found to be bacterially infected, the teas fermented on zinc sheets were invariably the better, being brighter and possessing more thickness on the palate, *i.e.*, as opposed to thick to look at."

Report from an Agency House.

"As you know, we have tried out your recommendations in regard to sterilisation of Factories on a comparatively speaking large scale, and I am glad to be able to state that in all cases we have found that good results were obtained immediately after sterilisation of fermenting and rolling room floors had been carried out, as also proper cleaning of machines, and there seems to be little doubt at the moment that bacteria have in the past

been responsible for a great deal of the poor tea, which has been put on the market."

The Manager of Garden 6 wrote :—

"When all the recommendations had been carried out the results obtained were remarkable. The infused leaf, especially in the second flush teas, is better than I ever remember seeing on this garden. Liquors also show a vast improvement both in quality and pungency, and I am very glad to say that they still continue to improve. It was demonstrated what a great difference takes place in leaf that has passed through a green-leaf sifter that has not been thoroughly cleaned. Provided that we can continue to pluck good leaf, and keep the factory under the same conditions of cleanliness during the season, I have great hopes of making teas fifty per cent. better that those made last year."

Extract of letter from Manager, Garden 39.

"Judging from Brokers reports a stewy character which was referred to several times has, since your instructions were adopted, not been referred to at all. I am of the opinion that there has been an improvement in my teas."

In addition to the cases quoted above and at intervals throughout this report a considerable amount of verbal evidence has been received pointing to the fact that teas made under conditions of strict cleanliness tend to show brighter infused leaf and brisker liquors than those subjected to bacterial infection.